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APPENDIX GA36a

LEVEL 4 ASSESSMENT SPECIFICATION

Student name:	Adam Bentley	Student ID number:	
Programme:	HNC/D MECHANICAL ENGINEERING		
Module:	ENGINEERING SCIENCE 1		
Module code:	M4X00385	Contribution to Overall Module Assessment (%):	30%
Lecturer:	Emily Nyathi	Internal Verifier:	Nigel Evans
Assignment Title:	PRACTICALS I & II (SIMPLE HARMONIC MOTION AND BENDING MOMENT)	Word count (or equivalent):	
Submission deadline:	13/01/2020	Return date of provisional marks & written feedback:	21/01/2020
Submission method:	All written assessments, where practical and possible, must be submitted via Turnitin unless otherwise instructed by the Lecturer. (Please DO NOT put this assessment specification into Turnitin or it will match many similarities with other students' submissions.) Alternative submission method (if applicable): Late submission of the assessment will result in a late penalty mark. Penalties for late submission: Up to one-week late, maximum mark of 40%. Over one week late, 0%. Only the Extenuating Circumstances Panel may approve a change to submission dates.		
Academic honesty / referencing:	Academic honesty is required. In the main body of your submission you must give credit to authors on whose research and ideas your work is based. Append to your submission a reference list that indicates the books, articles, etc. that you have used, cited or quoted in order to complete this assessment.		

STUDENT FEEDBACK FORM

This section details the extent to which the assessment criteria are demonstrated by you, which in turn determines your mark. The marks available for each category of skill are shown. Lecturers will use the space provided to comment on the achievement of the task(s), including those areas in which you have performed well and areas that would benefit from development/improvement

Generic Assessment Criteria	Marks available	Marks awarded
1. Engagement with Literature Skills		
You have researched very well on the background theory for both experiments. Keep on improving on your research skills.	25	15
2. Knowledge and Understanding Skills		
You have used appropriate equations to analyse your results and presented your findings in a logical manner.	30	20
3. Cognitive and Intellectual Skills		
You used graphs, tables and diagrams to explain your findings and also made some sound judgements from your findings and theoretical results.	15	11
4. Practical Application Skills		
You have identified applications of the SHM and Bending of Beams in the engineering sector and have also identified errors in your findings making sound recommendations.	25	18
5. Transferable Skills for Life and Professional Practice		
	5	3
Demonstrates very good skills for employment requiring the exercise of personal responsibility and decision-making.		

Assessment Mark (Assessment marks are subject to ratification at the Exam Board. These comments and marks are to give feedback on module work and are for guidance only until they are confirmed.)	Late Submission Penalties (tick if appropriate)		67%
	Up to 1 week late (40% Max)		
	Over 1 week late (0%)		

Experiment
Simple Harmonic Motion

Task A

Experiment 1 (part 1) Hooke's law

Abstract

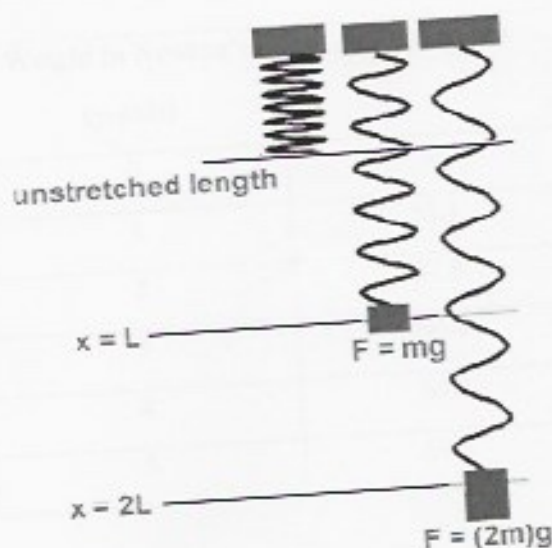
The goal of this experiment was to determine Hooke's Law for a mass connected to a spring and then investigate the Simple harmonic motion (SHM) of the mass on a spring. We will find the spring constant in each case and compare the results.

Introduction

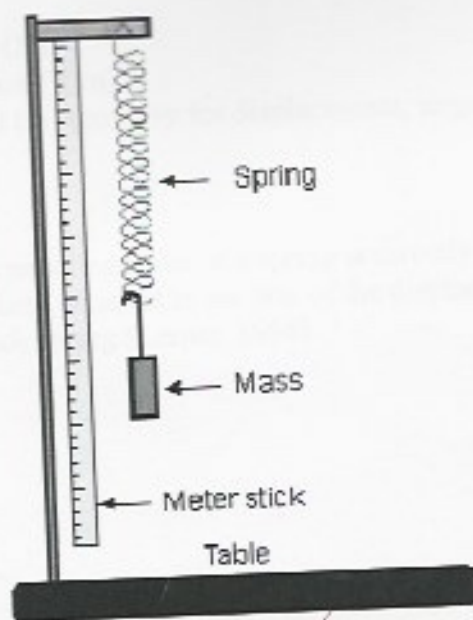
Hooke's Law is a principle of physics that states that the force needed to extend or compress a spring by some distance is proportional to that distance. The law is named after 17th century British physicist Robert Hooke, who sought to demonstrate the relationship between the forces applied to a spring and its elasticity (Wilson & Hernandez-Hall, 2009). He first stated the law in 1660 and then published the solution in 1678 "as the extension, so the force" or "the extension is proportional to the force" (Taylor, 2005).

PROCEDURE

1. Mount the spring so that it hangs vertically. Attach a mass hanger or a small mass and allow the system to stretch to an equilibrium state (the $x = L$ situation in the figure).



Place the bottom of the mass hanger or small mass even with a reference point on a meter stick as shown in the figure. This will be your zero for measurements.



3. Add masses in units of about 100 g up to a total of about 500 g. In each case, record the mass in grams. Then calculate the weight (weight = mass times g) in Newton's and record this amount. Record the amount of stretch from your reference point in centimetres for each mass. Divide by 100 to convert the stretch length to meters and record in the table.

Mass in kg	Weight in Newton's (y-axis)	Stretch in cm	Stretch in meters (x-axis)
0	0	0	0
0.101	1	52.1	0.52
0.204	2	57.9	0.58
0.306	3	60.4	0.60
0.408	4	64.2	0.64
0.506	5	69.3	0.69

Using the data collected from the experiment a line graph was created (see attached)

From the graph we can determine the spring constant, the following is Hooke's law formula for determining the spring constant of a spring:

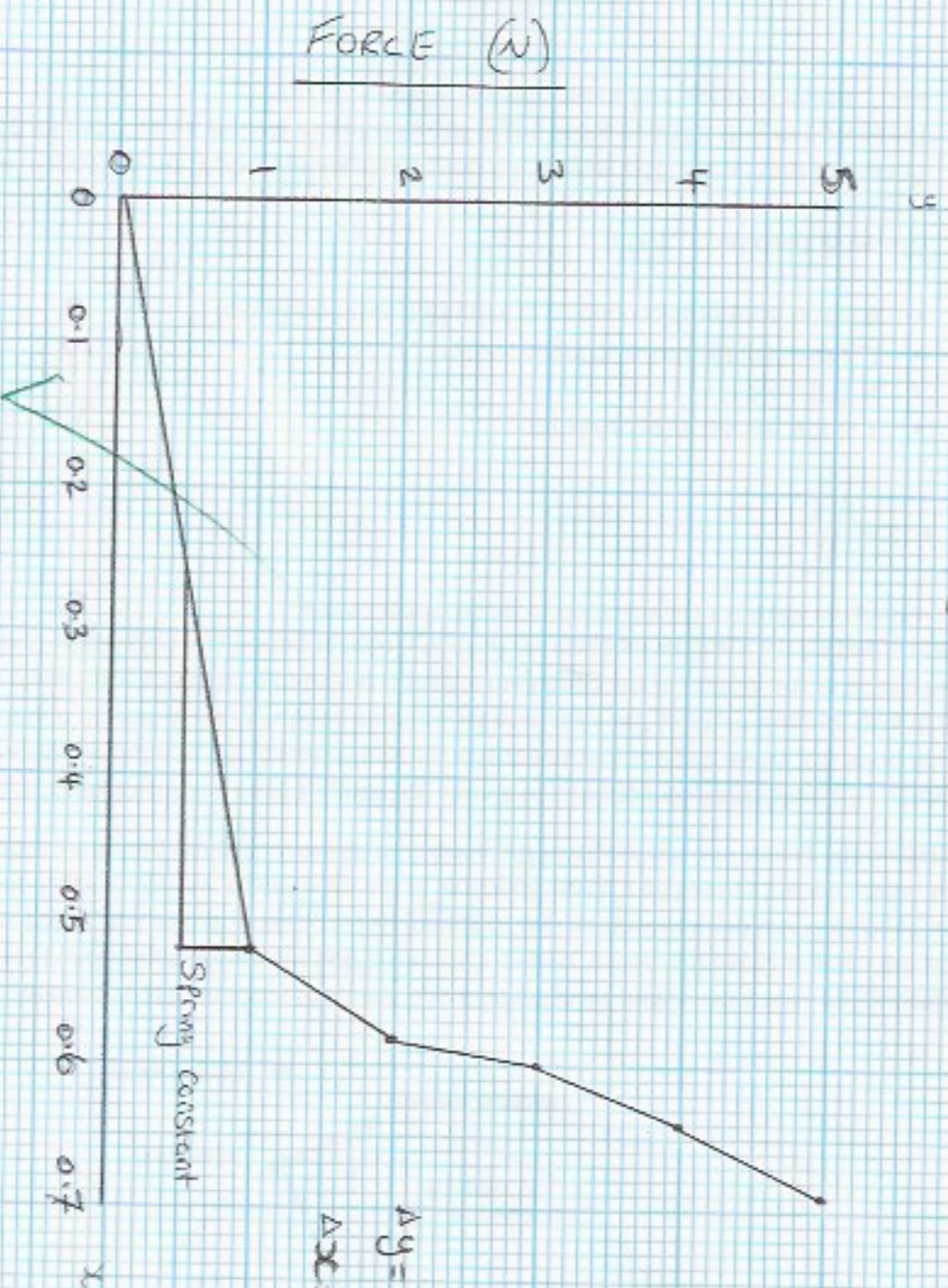
$$F = -k \cdot x$$

- Where F is the force (N)
- k is the spring constant (N/m)
- x is the displacement (m) (positive for displacement, negative for compression)

Hooke's Law states that the restoring force of a spring is directly proportional to a small displacement. In equation form, where x is the size of the displacement. The proportionality constant k is specific for each spring (Lerner, 1996)



Hooke's Law Spring constant



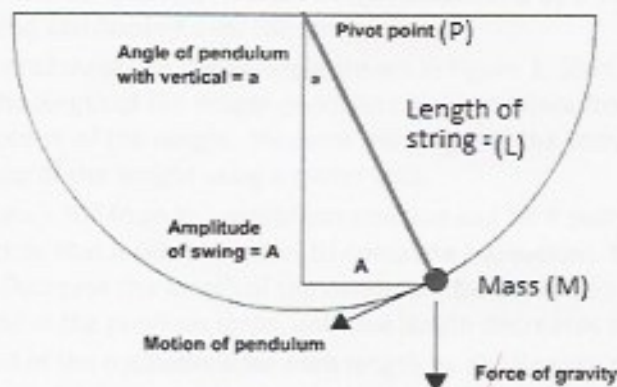
$$\Delta y = 1 - 0.5 = 0.5$$

$$\Delta x = 0.52 - 0.27 = 0.25$$

$$\frac{0.5}{0.25} = 2 \text{ N/m}$$

Task 2

Abstract - The goal of this experiment was to determine the effect of mass and length on the period of oscillation of a simple pendulum, whilst varying the pendulum length for a fixed mass. The results of this experiment are in close agreement with theory: mass had no measurable effect on the period of our pendulum, while the data for period verses length is well-described by a power-law relationship close to the theoretical square root dependence.



Introduction - For a pendulum swinging back and forth, the amount of time required to complete one full swing is called the period. Galileo discovered that the period depends only on the length of the pendulum and the acceleration due to gravity (Myers, 2006). In fact, the period and the length of the pendulum are related by a power function. In the experiment we will establish the relationship between the period and the length of the pendulum by measuring the period for differing lengths.

Theory - A simple pendulum consists of a mass (m) hanging from a string of length (L) and fixed at a pivot point (P). When displaced to an initial angle and released, the pendulum will swing back and forth with periodic motion. The equations for a simple pendulum show how to find the frequency and period of the motion. If the pendulum weight is pulled to a relatively small angle from the vertical and let go, it will swing back and forth at a regular period and frequency. These requirements allow for the equation to be relatively simple.

$$T = 2\pi\sqrt{\frac{L}{g}}$$

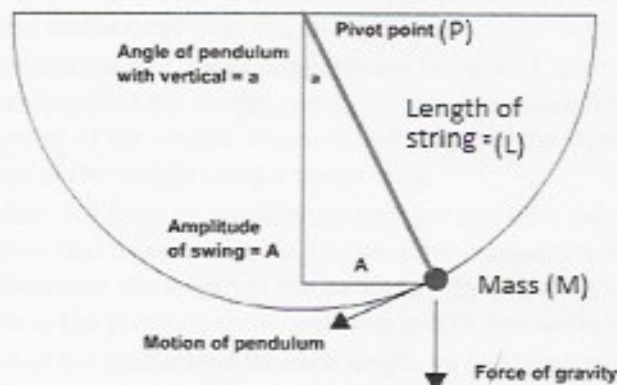
- T is the period in seconds (s)
- π (Pi) 3.14
- L is the length of the string in meters
- g is the acceleration due to gravity (9.8 m/s^2 on Earth)

(Baker & Blackburn, 2005)

Period of oscillation, The swing of a pendulum is dependent on its length, acceleration measured in g (9.81) and what angle the pendulum swings away from its horizontal axis in 0° , which is described as amplitude. (Gallant, 2012)

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Apparatus - The apparatus for this experiment consists of a support stand with a string hook, a small weight with a 44 cm length of light weight string, a meter stick, a protractor and a stop watch.

Procedure

1. The simple pendulum is composed of a small weight suspended by a 44cm light string, which was looped at the end and hooked over the string hook.
2. Prepare an Excel spreadsheet like the example shown in Figure 1. Start with the string at full length of 0.44 m. The length of the simple pendulum is the distance from the point of suspension to the centre of the weight. Measure the length of the string from the point of suspension to the top of the weight using a meter stick.
3. Displace the pendulum 30° from its equilibrium position and let it swing back and forth. Measure the total time that it takes to make 10 complete oscillations. Recording the time in your spreadsheet. Decrease the length of the pendulum by about 0.11 m and repeat the measurements made in the previous steps, until the length decreases to approximately 0.1 m.
4. Calculate the period of the oscillations for each length by dividing the total time by the number of oscillations, which is 10. Record the values in the appropriate column of the data table.

(Figure 1)

Figure 1. Excel spreadsheet for recording and analysing data.

Experiment 1						
Length (M)	Time for 10 oscillations	Period (s)	Theoretical Period (s)	Angle °	Mass (g)	
0.44	13.09s	1.31s	1.33s	30°	100 g	
0.33	11.37s	1.14s	1.15s	30°	100 g	
0.22	09.27s	0.94s	0.94s	30°	100 g	
0.11	06.62s	0.66s	0.67s	30°	100 g	
Experiment 2						
Length (M)	Time for 10 oscillations	Period (s)	Theoretical Period (s)	Angle °	Mass (g)	
0.27	10.4s	1.04s	1.04 s	30°	50 g	
0.24	9.8s	0.98s	0.98 s	30°	50 g	
0.20	9.1s	0.91s	0.897 s	30°	50 g	
0.16	8.1s	0.81s	0.80 s	30°	50 g	

RESULTS

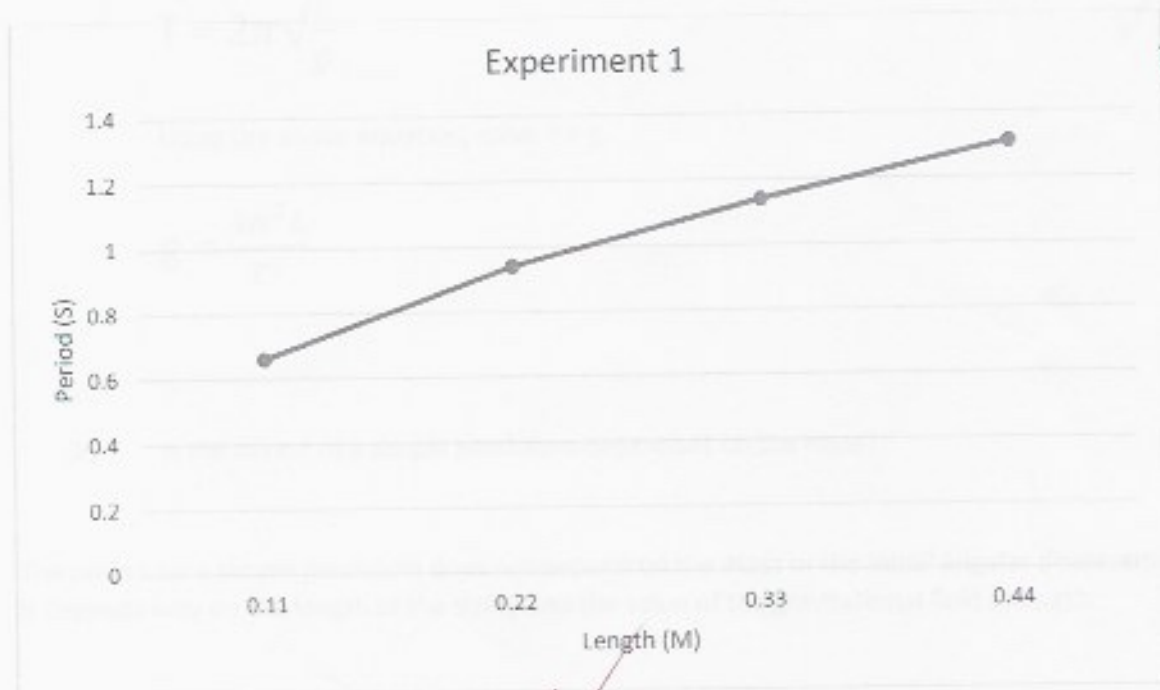
In this experiment, we investigated the dependence of the period of a pendulum on two variables, the mass of the weight and the length of the string. We followed the instructions and tried to keep the amplitude constant for all the measurements so that it would not affect the result, because we learned that in the case of a pendulum, large amplitude can change the period. We found that changing the mass from 50 grams to 100 grams did not seem to have much effect on the period, so we concluded that the period is independent of the mass.

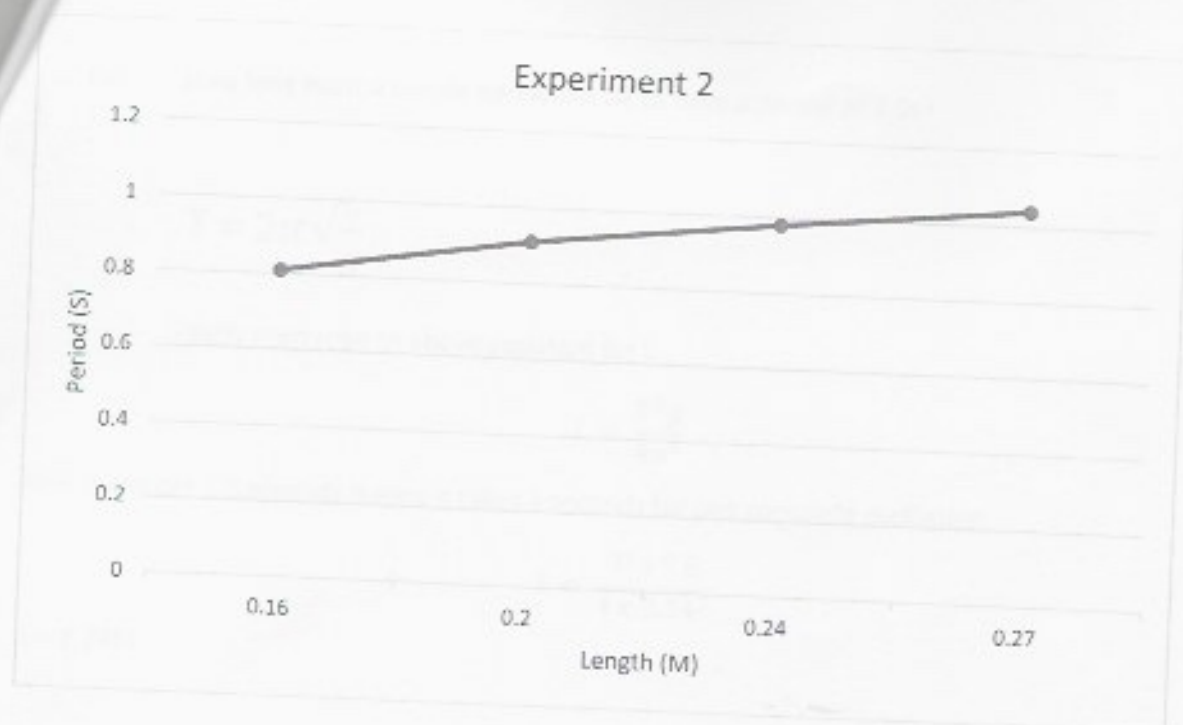
In the case of changing the length of the string, we used strings from 0.11m to 0.44m long in experiment 1 and strings lengths from 0.27m to 0.16m in experiment 2, between the point of suspension and the centre of the bob. There was an uncertainty in the measured length because we had to estimate the centre of the bob, and the point of suspension. We believe this error to have been less than 10mm (or 0.01m), so for the 0.44m string, the uncertainty was only $0.01/0.44 = 0.02\%$, while for the shortest string, it was $0.01/0.11 = 0.09\%$. We assumed that the mass of the string was negligible, compared to that of the bob. We measured the period using a stopwatch for 10 swings. It was difficult to accurately record a precise time, to better than 1 second. So, if 10 swings took 8 seconds, an error of one second would be $1/8$ or 12.5%, which would be the largest contributor to the error. If we had used 100 swings for each trial the error would be less but we did not have sufficient time.

CONCLUSION

When we charted and made a trend line with Excel, the period was proportional to the length raised to the 0.45 power. This is to be compared with the value in the text that states that the period is proportional to the square root of the length (0.5 power). This is an error of about 10%, which seems reasonable, compared to the timing error.

The experiment could be improved by using wire, which doesn't stretch, instead of string, a greater number of swings and perhaps a photogate timer to make very precise measurements of the period time.



**Task B**

- (i) The period of oscillation of an ideal, simple pendulum depends on the length, L , of the pendulum and the acceleration of gravity, g and is given by the following equation:

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Using the above equation, solve for g .

$$g = \frac{4\pi^2 L}{T^2}$$

- (ii) Is the period of a simple pendulum dependant on the mass?

The period for a simple pendulum does not depend on the mass or the initial angular displacement, it depends only on the length of the string and the value of the gravitational field strength.

- (iii) How long must a simple pendulum be to have a period of 1.5s?

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Firstly rearrange to above equation for L

$$L = \frac{T^2 g}{4\pi^2}$$

One swing per 1.5 seconds means it takes 3 seconds for one complete oscillation

$$L = \frac{3^2 \times 9.8}{4 \times 3.14^2}$$

$$L = 2.24\text{M}$$

- (iv) Assuming you are safely located on the moon, and are provided with a simple pendulum, stopwatch and a metre rule, is it possible to determine the acceleration due to gravity on the moon using only these items?

Having a pendulum with multiple masses and lengths, you are able to calculate the approximate acceleration due to gravity on anywhere, including the moon.

if I WERE on the moon, I would use a mass attached to a length of string, elevate it and drop it to measure its period.

Example,

If the period was 2.5 seconds, and I used a 0.25m length of string.

Rearrange $T = 2\pi\sqrt{\frac{L}{g}}$ for g.

$$g = \frac{4\pi^2 L}{T^2}$$

this gives me the calculation I need to calculate the acceleration, where;

T=2.5 and L=0.25

$$g = \frac{4\pi^2(0.25\text{ m})}{(2.5\text{ s})^2}$$

so,

$$g = \frac{9.9\text{ m}}{6.3\text{ s}^2}$$

resulting in $= 1.6\text{m/s}^2$

References

Bibliography

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- Gallant, J. (2012). *Doing Physics with scientific note book*.
- Lerner, L. S. (1996). *Physics for scientists and engineers*.
- Myers, R. L. (2006). *The basics of physics*.
- Stewart, J., Redlin, L., & Watson, S. (2012). *Trigonometry*.
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- Wilson, J. D., & Hernandez-Hall, C. A. (2009). *Physics Laboratory Experiments*.

Experiment: Bending moment in Beams

Task A

Abstract

At any cross section of a material under load, there will be a shear and bending factor to maintain equal forces, (equilibrium). A bending moment is when a structure is under load from an external force or 'moment' is applied to it, causing the structure to try to bend/shear (Kassimali, 2010)

Objectives:

The aim of the experiment is to comprehend the action of moment of resistance in a beam and to measure the bending moment at the normal section of a loaded beam and to check its agreement with theory.

Introduction

A bending moment (BM) is a measure of the bending effect that can occur when an external force (or moment) is applied to a structural element. This concept is important in structural engineering as it can be used to calculate where, and how much bending may occur when forces are applied.

The most common structural element that is subject to bending moments is the beam, which may bend when loaded at any point along its length.

Failure can occur due to bending when the tensile stress exerted by a force is equivalent to or greater than the ultimate strength (or yield stress) of the element. However, although the mechanisms are different, a beam may fail due to shear forces before failure in bending.

If a beam is not well-restrained, a bending force may cause it to rotate about a pivot point.

To calculate the bending moment, the magnitude of the force is multiplied by the distance of the force from the point of support. (Megson, 1996)

Equipment used

To carry out the experiment we used a Beam with cut section, joined with a Newton meter (spring load gauge) which was set upon 2 pivot points, 3 load hangers and various weights. We measured with a meter rule.

Procedure

The beam was set upon the pivot points and the spring load gauge was adjusted until the beam was level and the gauge read zero. Then Measurements were taken, the full span of the beam, the measurements from the end of the beam to each pivot point, the measurements from the end of the beam to each of the load hangers and the measurement from the centre of the beam to the spring load gauge. A mass was then applied to each of the load hangers causing the beam to sag. Using the spring load gauge the beam was brought back to its horizontal and a reading was taking from the spring load gauge. The experiment was repeated with different loads being added to the load hangers.

Diagram of bending moment experiment including dimensions and masses

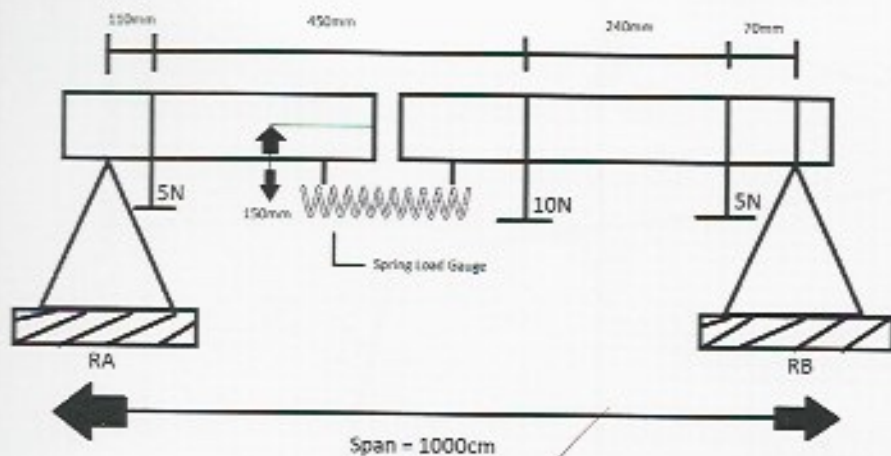


Table of results

	L	A	B	WT1 (N)	P1	WT2 (N)	P2	WT3 (N)	P3	BEFORE (KG)	AFTER
TEST1	1000	30	900	5	110	10	560	5	800	1	2.2
TEST2	1000	30	900	10	110	15	560	10	800	1	3.3

REACTIONS	R1+R2	R2	R1
TEST1	20	10.15	9.85
TEST2	35	17.5	17.5

BM CALCULATED

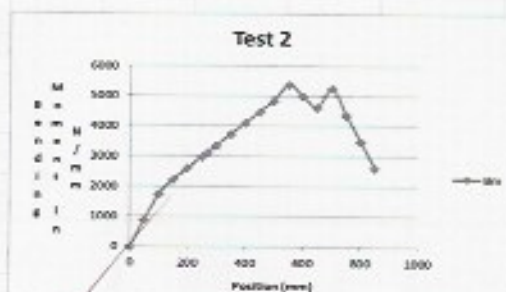
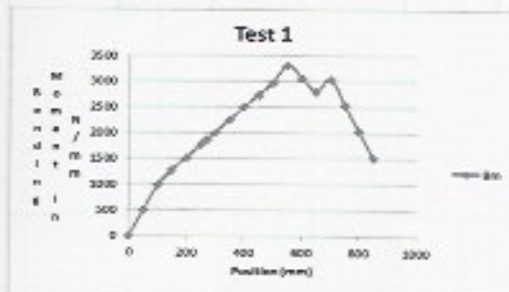
TEST 1

X	Bm	Measured result
0	0	
50	492.5	
100	985	
150	1277.5	
200	1520	
250	1762.5	
270	1859.5	180
300	2005	
350	2247.5	
400	2490	
450	2732.5	
500	2975	
550	3217.5	
600	3060	
650	2802.5	
700	3045	
750	2537.5	
800	2030	
850	1522.5	

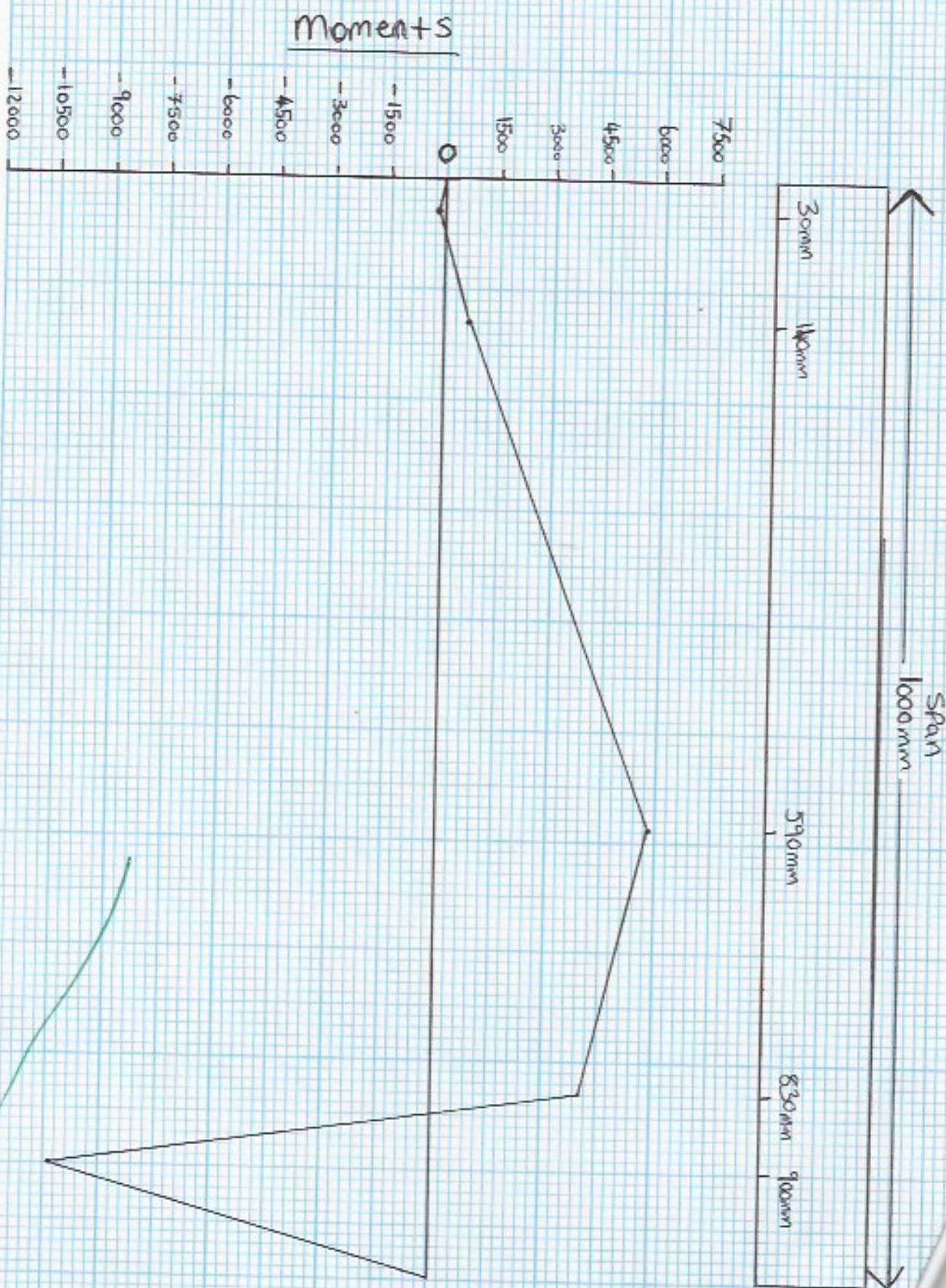
TEST 2

X	Bm	Measured result
0	0	
50	875	
100	1750	
150	2225	
200	2600	
250	2975	
270	3125	
300	3350	
350	3725	
400	4100	
450	4475	
500	4850	
550	5375	
600	5000	
650	4625	
700	5250	
750	4375	
800	3500	
850	2625	

Graph of results



Bending moments diagram



Length (mm)

Shear force diagram

1000mm span

119mm

590mm

83mm

900mm

label your principal values

Force (N)

10.7
8.4
5
3.4
0
-5
-6.6
-10
-11.6
-15

Length (mm)



Observations

To gain more accurate results, the environment and equipment used to carry out the experiment could have been improved. The work surface was sturdy but not level, the beam was set up without the use of a spirit level. The weights used were taken at face value and not accurately weighed. The distance between weights were recorded with a meter rule, to obtain a more accurate measurement a Vernier calliper could have been used. Time was also an issue, the experiment was carried by a large group and there was only a limited time available on the apparatus before the next person had to use and record their results.

Conclusion

Observing the table and graph of results from the 2 experiments it shows that the Bending moments (N/MM) are double when the weight was doubled

Results

$$R_A + R_B = 20N$$

$$5 \times 110mm + 10 \times 560mm + 5 \times 800mm = R_B \times 870mm$$

$$550NM + 5600 NM + 4000 NM = R_B \times 870mm$$

$$10150 = R_B \times 870mm$$

$$R_B = \frac{101.5}{8.7}$$

$$R_B = 11.6 NM$$

$$R_A + 11.6 = 20$$

$$R_A = 8.4 N$$

$$R_B = 11.6 N$$

Shear force

$$\text{Shear force @ A} = 8.4$$

$$\text{Shear force @ B} = 8.4 - 5 = 3.4$$

$$\text{Shear force @ C} = 3.4 - 10 = -6.6$$

$$\text{Shear force @ D} = -6.6 - 5 = -11.6$$

$$\text{Shear force @ E} = 11.6 + 11.6 = 0$$

(See attached shear force diagram)

Bending Moment

Bending moment @ A = $-8.4\text{N} \times 30\text{mm} = -252$

Bending moment @ B = $5\text{N} \times 140\text{mm} = 700$

Bending moment @ C = $10\text{N} \times 590\text{mm} = 5900$

Bending moment @ D = $5\text{N} \times 830\text{mm} = 4150$

Bending moment @ E = $-11.6\text{N} \times 900\text{mm} = -10440$

(See attached Bending moments diagram)

Task B

- (i) Did the bending moment double when the load was double in part 1 of the experiment?

Observing the table and graph of results from the 2 experiments it shows that the Bending moments (N/MM) are double when the weight was doubled

- (ii) Compute the average figure which expresses the comparison between the experiment and the theoretical bending moments (use either ratio or a percentage error)

- (iii) Did the experiment verify the theory?

References.

Bibliography

Kassimali, A. (2010). *Structural analysis*.

Megson, T. (1996). *Structural and stress analysis*.

Websites used for research -

https://www.designingbuildings.co.uk/wiki/Bending_moment